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**THE MEMPHIS SYSTEM OF  
SEWERAGE AT MEMPHIS  
AND ELSEWHERE.**





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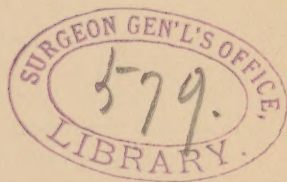
BY GEO. E. WARING, JR., M. INST. C. E.,  
*Newport, R. I.*

PRESENTED AT THE TWENTIETH ANNUAL MEETING OF THE AMERICAN  
PUBLIC HEALTH ASSOCIATION, HELD IN THE CITY OF MEXICO.

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## THE MEMPHIS SYSTEM OF SEWERAGE AT MEMPHIS AND ELSEWHERE.

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The system of sewerage first constructed at Memphis in 1880, was first formulated in a paper read before this Association at its annual meeting of November 18, 1879. But for the dire need of that stricken city, and but for its great financial distress, the system would probably have existed to this day only in the reproduction of that article in the fifth volume of the published reports of this Association. Under ordinary circumstances it might have been regarded as a promising theory, but probably no town would have ventured on the experiment of putting it into practice.

As soon as the paper was read, its suggestions were caught at, as a possible saving straw, by the Memphis delegation at the meeting, and were by them urged on the attention of the commission of the National Board of Health charged with the sanitary questions at Memphis. The disastrous yellow-fever epidemics of 1878 and 1879 left that filth-sodden city partly depopulated, shorn of credit, and shuddering under a fear of the continuance of yellow-fever. As consulting engineer of the commission, I suggested the outline of a plan by which the system described could be applied to Memphis.

A sewerage plan on the combined system had some years earlier been prepared by Mr. George Hermany, C. E., of Louisville, with whom Mr. E. S. Chesbrough, C. E., of Chicago, had acted as consulting engineer. Mr. Hermany appeared before the commission in Memphis by its invitation, and urged the wisdom of doing only what had been done before. He expressed his interest in the scheme proposed, and in its trial as an experiment, but he could not advise its adoption as a practical system of town drainage. Mr. Chesbrough told me before the work was begun that he was glad that the system was to be tried, but that he himself would never have taken the responsibility of recommending it.

After long and thorough discussion, and mainly because it was the only thing that could be afforded, the commission, on the 26th of November, unanimously recommended this system to the authorities of Memphis. The plan, as suggested, included a large number of manholes, and rather large main sewers along the outlet valley. When the estimate came to be considered in detail by the council, it was decided, largely

by the advice of the mayor (Dr. Porter), to omit the manholes, and to make the mains only large enough for the needs of the next few years; the argument being used that, if manholes were found necessary, they could be built later, and that when larger mains should become necessary, the city could then better afford to build them. Dr. Porter especially urged these considerations as reasons why this system was best suited to the case. In plain English, the city could afford to do nothing else, and it could not afford to do even this completely.

A working plan was ordered. When submitted, it was actively discussed by the council, and was at length adopted. On the 28th of December, Dr. Porter called me to Memphis by telegraph, as there was a strong opposition to the plan. On January 1, 1880, I was cross-examined before the council for three hours and a half. It was decided that the recommendations should be presented to a meeting of the citizens, with the council's full endorsement. January 2, I discussed the matter actively, and against some very acrimonious opposition, at a large meeting in the hall of the Chamber of Commerce, with the ultimate effect of a strong affirmative vote, and only one voice in opposition.

From this time the work went on rapidly. Ground was broken for the laying of the pipes January 21, 1880. Early in June, it not being considered safe to disturb the soil during the hot season, the work was not allowed to proceed further. In twenty weeks, during five of which, in the aggregate, work was impossible because of rain, and during other five weeks was made difficult from the effect of rain, we constructed over eighteen miles of sewers, including all the main sewers, at a cost of about \$137,000. This ended my connection with the original work, though I am the city's consulting engineer for sewers and all sanitary construction.

The work above described has been popularly credited with the conversion of Memphis from a pest-hole to a habitable town. What its exact effect may have been on the health of this city can never be determined. It may largely have caused it, or it may largely only have coincided with it. The paving of the streets and the improving of the water-supply have surely had great effect.

Mr. Odell, who was an engineer employed in the construction, wrote a paper for the American Society of Civil Engineers, giving a careful description of the system. He closed as follows :

With the results already achieved by this small-pipe system of sewerage, it seems safe to predict that a new era has been inaugurated, and that the coming years will witness great modifications in the prevailing methods of sewerage.

This paper was the subject of much discussion, favorable and unfavorable. The criticisms related to the general applicability of the system, the conditions of Memphis being exceptional; to the superiority of the combined system; to the doubtful expediency of depending on self-acting flush-tanks, and of rejecting rain-water as a means of flushing; to the probable cost of maintenance; to the probable filling of sewers with



grease from sinks; to the absence of manholes; to the short distance below the flush-tank for which the flushing would be effective; and to the relative cost of the two systems.

Mr. Bogart said,—

If this system that has been adopted does not work at all, as has been prophesied, or only works for a short time, the fact that it is cheap will not make it economical; but if it does work for a few years, and even if after that time it does require additions, as, for instance, manholes, the beneficial results to the health of that city will doubtless be enormous. The fact is, that a system of sewerage has been put in at Memphis which Memphis was able to pay for, and I understand that, without some system of sewerage, there was a probability that the city would have to be abandoned as a place of residence.

Mr. Croes said,—

I do not understand that the entire separation of sewage and storm-water, which Mr. Waring advocates, and which has been carried out at Memphis, and recommended for Newport, Stamford, and other places, has been practised anywhere in England. In what is there called "the separate system," the rain-water from roofs and back yards is allowed to enter the sewer, but the street-wash is excluded. The Memphis work is attracting as much attention there as it does in this country, and the results of a continued trial of it are looked for with great interest. The omission of manholes does not seem to be a part of the "system." In this case it was an expedient adopted to reduce the first cost to the lowest possible point, in order to enable anything at all to be done.

In closing the discussion, I said,—

That it (the sewerage of Memphis) is by any means perfect in its details, I do not pretend. That these details will not be greatly improved by the efforts of others, it would be fatuous to suppose. Had I had more money to spend in Memphis, some of them would have been more complete than they are. At the same time, I am convinced that the main features of that system are strictly correct.

November 18, 1882, the city engineer of Memphis reported,—

The system, in the main, has so far worked admirably, and has given entire satisfaction;

And in November, 1886,—

Thus far no fault can be found with the manner in which the system has worked. The excessive quantity of mud in the water is our chief source of trouble. The small,  $\frac{3}{4}$ -inch supply pipes to the flush-tanks become clogged with mud. . . . With clear-settled or filtered water all this trouble will cease, and the whole system work to a charm.

October 12, 1888, Mr. R. Frank Hartford, the engineer in charge of the sewers, wrote me,—

Your letter of the 18th ult., addressed to Mayor Merriwether, was handed to me for reply. Since it was given me I have had a thorough examination of the system made. Every line of sewers, whether of low or high gradient, is thoroughly clean. We have no fouling upon any line, and upon many I am certain that a velocity (mean) of not even  $1\frac{1}{2}$  feet is reached. On one of low gradient (1 in 200) in a distance of 700 feet the maximum depth of flow is not more than 2 inches (it is a 6-inch line), or perhaps 3 inches

with the flush; yet, even here, where the mean velocity cannot exceed 1.3 feet, the pipe is perfectly clean. We have, it is true, occasional stoppages, but they are invariably caused by foreign substances, such as sticks, rags, etc., never by deposit of sewage. With a good flush at the head of the line, I would not hesitate to lay 6-inch at 1 in 300, feeling confident that no fouling would occur. I should want to be sure of the flush, however, about once in twenty hours.

In his report of that year, this officer says,—

I earnestly recommend that a skilled inspector be employed to examine, test, and report upon work done under the plumbing ordinances. Bad work has now become the common practice, and it is clearly attributable to the lack of intelligent supervision.

How long this “bad work” had been the common practice is not stated, but in recent years there have been reports and rumors of an inordinate number of stoppages in the system, one authority placing it at 2,000 in one year, mainly, of course, in house drains, and due largely to a practice permitted among plumbers of forcing obstructions out of water-closet traps with plungers, driving forward into the drain and sewer masses of material which they were not intended to receive in such compact form.

The engineering officers of Memphis have taken great interest in the sewers of that city, and have applied, in recent work, a number of improvements. It is not unnatural that they should take to themselves the credit for the successful working of the system at large. It is a source of satisfaction to me that I was able to point out the line of procedure on which they have made such advance.

At the same time I am not willing that the obstructions which have formed in the Memphis sewers, and the “fungus” which is reported to have grown in some of them, should be laid to my charge. To what degree these defects have been due to negligent management and to defective flushing I am not in a position to determine, but there can be no doubt that defective construction, and the consequently defective operation of the flush-tanks, peculiar to Memphis, has withheld from these sewers the regular daily cleansing, which was, at the outset, provided as essential to their successful working.

It is doubtless largely due to more perfect flushing, and to improvements which have been engrafted upon this system in its later introduction elsewhere, that the experience of Memphis, in the matter of obstructions has been left quite unique, as would appear from later portions of this paper.

As the result of criticisms about Memphis, especially with reference to the great number of stoppages, I sent a circular letter to the engineers in charge of sewers in the various towns where I knew this system to be in use, as follows:

NEWPORT, R. I., November 19, 1891.

DEAR SIR: The statement has recently been made that the sewers of Memphis, Tenn., as constructed by me, have had during ten years 1,128 stoppages. In 1884-'86 there were said to have been 391 stoppages. The cost of removing stoppages was \$11,006.10. The



cost, in the same period, of cleaning sewers was \$6,178.08. The average length of sewer in this period was about 34 miles. It is stated that "in opening the older lines of the Waring system we found the entire pipe coated with a growth of fungus from  $\frac{1}{2}$  to  $1\frac{1}{2}$  inches thick, which could only be removed by passing steel brushes through the pipes, the usual flushing of the sewers not being able to detach this growth or prevent its accumulation."

The flush-tanks used on these sewers were the old form of Field tank, which soon became inoperative, partly from the silting up of the supply-pipes from the very muddy water-supply, and partly by the rust blisters on the inside of the descending limb of the siphon, these blisters catching the water and preventing it from falling free to the trap below. These defects have been repeatedly pointed out, but at last accounts had not been remedied. By reason of them, the sewers have been very inadequately flushed.

Will you do me the favor to give me your experience with your sewers in the matter of obstructions in the 6-inch sewers, of the growth of fungus therein, and of the general cleanliness and smooth working of the 6-inch portion of the system. Also, if you are willing to take the trouble, give me separately the mileage of 6-inch pipes, the number of obstructions, the cost of removing them and of cleaning the 6-inch pipes.

I am sorry to have to ask this favor of you, but I believe that the experience of Memphis has been entirely exceptional, that most of the obstructions occurred in house drains, that most of the obstructions in sewers resulted from the use of "plungers" in cleaning water-closets, and that the principal trouble is due to the failure of the antiquated flush-tanks in use there.

I should also like to know to what extent you have found it necessary to use a steel brush, or its equivalent, to remove fungus from the sewers.

Very truly yours,

GEO. E. WARING, JR.

I received replies concerning twenty-two different towns, from which I make the following extracts, covering the whole list, and giving the exact spirit of the reply in each case.

Omaha, Neb. (Geo. W. Tillson, Esq., C. E., City Engineer) :

We have now 7 1-10 miles of 6-inch pipe sewers in operation, mainly in the residence portion of the city. On account of the number of hydraulic elevators in our large business blocks, we have relaid a number of sewers originally built of 6-inch pipe. In these sewers we did have considerable trouble with the fungous growth mentioned in the Memphis report. During 1887 we had three stoppages in the Waring system; in 1888, four; in 1889, four, and in 1890, twelve. During these years the mileage of the Waring system was greater than at present, as but little relaying had then been done, especially in 1887. Some of our residence lines that have been in use six or seven years, have never been stopped up, and others but once. Two lines in the business portion give practically all the trouble. We are not obliged to use steel scrapers to remove any fungus; in fact we have not dragged *anything through* the sewers for the past three years, though the sewer inspector occasionally flushes the sewers with the fire pressure. He says they might run all right without it.

Lenox, Mass. (T. Post, Esq., Sewer Commissioner) :

During the past four years, while I have had the charge of the Lenox sewers, there have been but two stoppages of street mains, and those occurred on a short street, and very near together, and were caused by breakages in the main, the town having undermined the sewer main in constructing a large main drain to carry off surface water from a portion of the village. No trouble has been experienced on account of any fungous growth in our 6-inch sewers, or in any of our sewers, and all seem to work smoothly and to keep clean easily. . . . We have about three miles of 6-inch pipes. . . . We

purchased a steel brush, but it has only been used once, and then only to clear out a new street main after its completion and before commencing to use the main. Have never known of any obstructions in our 6-inch mains in the ten years of their existence prior to 1887.

Mr. J. H. Haney, C. E., of Little Rock, Ark., who has introduced the system in many towns in the South-west, says,—

I make occasional inquiries about my sewers, and am always told that they are in good order, work like a charm, and give perfect satisfaction and no trouble at all, but I have no information that can be statistically formulated. . . . As to the accumulation of fungus in pipe sewers of small dimensions, I have never seen anything of the kind. I have seen heavy coatings of grease so deposited, which has the appearance of a white, spongy fungus, and a close-fitting wire brush would be the best means of removing this, as the most powerful flushing of cold water will fail to entirely remove such a deposit. While I do not question the good faith of the Memphis engineer who reports the fungous growth in the 6-inch laterals of that city, at the same time it would seem that the oldest 6- and 8-inch laterals of this city ought to be similarly affected. But it is possible that the old form of Field's siphon used so extensively in Memphis has become choked with mud and rust to such an extent as to become inoperative, so that a real fungous growth has appeared, and for lack of efficient flushing, has become too strong for removal by any other means than the brush. Such, however, has not been the case here, and we have quite a number of the old form of siphon, the same as used in Memphis, dating as far back as 1882, or only two years after the completion of the original Memphis system constructed under your supervision.

Mr. C. P. Bassett, C. E., says,—

On steep grades in Corning and Englewood 6-inch pipes were used, and the sewers have kept entirely free from stoppages. A fungous growth developed when the sewers were first placed in operation, but soon disappeared. . . . I may also call your attention to the experience on house connections in East Orange. Here, for the first time I believe, connections were laid with the same care and under the same specifications as were the sewers, lampholes replacing manholes. In three years 10 miles of 4-inch connections—minimum grades 1 in 200—developed less than a half dozen stoppages, and these, with one exception, were removed by wire without digging up the pipe.

Lincoln, Neb. (Adna Dobson, Esq., City Engineer) :

We have only about two miles of 6-inch pipe, out of a total of about twenty-two miles. The whole system is in good working condition, and during the past year we have had only five stoppages, all of which occurred in the 6-inch pipe. . . . We have had no trouble with fungous growth, and all of our system is in a clean, smooth-working condition. We have had no occasion to use a steel broom or its equivalent.

Mr. Wm. B. Landreth, C. E., says,—

I have laid but one mile of 6-inch sewers, that mile being at Round Lake. I understand that the Round Lake 6-inch sewers have caused no trouble when well flushed, though a portion were laid on a 4-10 grade. I have had no trouble with sewer fungus, as it has always been readily detached by flushing.

Washington, Pa. (Albert Smith, Esq., C. E., Borough Engineer) :

The length of sewers of the various sizes, completed to date, are as follows: 15-inch, 7,983.5 ft.; 12-inch, 1,719 ft.; 10-inch, 1,311.5 ft.; 8-inch, 9,316 ft.; 6-inch, 13,233 ft.; 4-inch



12,466.5 ft; or a total of 46,029 ft., or 8.72 miles. The 12,466.5 ft., or 2.36 miles of 4-inch sewers consists of house branches (629 in number), which were laid to the curb by the borough and assessed on the properties. We have constructed 40 inspection chambers, 32 manholes, and 15 flush-tanks. These sewers have been in use from two to five months. So far the only obstruction which has occurred on the whole system has been that caused by an "oyster can" in a house branch, a thing which could only have happened through a flagrant violation of law and common sense on the part of the property-holder. There has been no instance of stoppage in any line of 6-, 8-, 10-, 12-, or 15-inch pipe, nor has one dollar been expended so far in cleaning them. . . . As to fungus in pipes, I have been unable to detect any such growth so far, and there is but little sliming up of the sides of the pipes. A recent examination, embracing the opening up of about half the manholes, revealed only one at which the odor was perceptible at the street surface.

### Mount Holly, N. J. (Geo. E. Gaskill, Esq., C. E.) :

We have only had a stoppage in one street in the whole system, which was caused, first, by one of our plumbers opening one of the branches, and allowing it to remain over night, and while open a rain came and partly filled the pipe with sand; then about 500 feet above that point is located a large boarding-school, and the same plumber made the connection to the sewer from the school building, and must have left some large openings, from the articles that were found in the sewer-pipe—old shirts, house-cloths, and among other things a piece of wood as large as a man's arm, and 10 inches long. A 6-inch pipe would hardly carry such things very well. . . . All other parts of the system have worked all right, and we have had no other stoppages of any kind. . . . We have not had any occasion to use a brush of any kind, or to do any cleaning except the regular flushing. . . . We have not been troubled with any fungous growth on the inside of the pipes, and we are very well satisfied with the system. We have in all about  $3\frac{1}{4}$  miles of pipe, about 1,400 feet of which is 10-inch pipe, 2,806 feet of 8-inch pipe, and the remainder of the system is of 6-inch pipe. The total cost of the system, including survey, plans, my services superintending the work of construction, and your own services and expenses as consulting engineer, was \$8,632.60 [\$2,656.18 per mile].

Pullman, Ill. (Mr. Benezette Williams, C. E., sends the following quotation from an officer of that town) :

None of the vitrified sewer pipes here have ever exhibited any traces of fungus, and they are as clean to-day as they were the day they were first put in. The scour is sufficient to keep these pipes clean. Not oftener than once a week, and sometimes at intervals of a month, one of the 6-inch block sewers will need a rod, and at rare intervals the stoppage has to be removed by digging up the pipe. The obstruction is never caused by sewage, but by foreign matter, such as cloths, old shoes, and, oftener than in any other way, by table-knives, forks, and spoons, which careless housewives must throw with other matter into closets. Children at play sometimes put blocks of wood in the closets; and such matter, as any one can readily see, is liable to clog a 6-inch pipe. In some cases we have taken out old quilts and clothes, as well as sticks and bricks which boys must have dropped into manholes. For their legitimate use as conveyors of sewage, I find our 6-inch pipes, as well as the larger ones, clean and bright. Even the ordinary flushing is very rarely necessary, the wash and scour of the sewage keeping the pipes clean. I send you some printed matter giving the lengths of pipe of various kinds which you put in here.

Mr. Williams adds,—

In looking over the printed matter to which Mr. Doty refers, I do not find the lengths of sewer at Pullman. My recollection is, however, that there are five or six miles.



## Kalamazoo, Mich. (George S. Pierson, Esq., C. E.):

We have had no difficulty here commensurate with that at Memphis, as indicated by their reports. There is a slight growth of fungus in the sewers here, but before it attains any appreciable thickness the flakes of fungus become detached and pass onward to the outlet, so that the surface of the pipes are found practically clean. Very few of the lines have ever had anything similar to a brush passed through them, and some of them have been in use about ten years. We have never used any mechanical means other than the discharge from the flush-tanks for removing accumulations in the sewers, except in cases of solid substances causing stoppages. So far as I can remember, we have never had to exceed three stoppages in any one year which could not be removed by inserting a hose at the manhole or lamphole. The average cost of maintaining the system since its inception, previous to 1890, I find, by reference to the annual report for that year, to be \$232.65. This includes removal of stoppages and a semi-weekly inspection of the sewers. Nearly all the stoppages have occurred in the 6-inch lines in the business part of the city. There has been scarcely any trouble with the 6-inch lines in the residence portion of the city. I think, however, the sewers in Kalamazoo have exceptionally good care on the part of the citizens. I have sent you by this mail a copy of the last annual report, from which you can gather the information you seek as to lengths of the different sizes of pipe, etc.

The schedule shows 31,055 feet of 6-inch sewers; that the construction of the system was begun in 1882; and that nearly one half of the system was built in 1882 and 1883.

## Alameda, Cal. (V. M. Frodden, Esq., Superintendent of streets):

I took charge of the streets and sewers February 15, 1890, when I found that two of our receiving sewers were almost choked up, one with sand, and the other with mud and sand. Causes: some defective sewers which emptied into them, and improper care in looking after the sewers. The city had employed two or three men all winter to clean out these sewers, but with poor success. They would drag a sack of sand through these sewers from one manhole to the other, to get the sand out of the sewer. I saw right away that that did not do the work, so I had a steel wire flue brush made to drag through the sewer, and succeeded in cleaning both sewers thoroughly in about three months. I took hundreds of yards of sand out of these receiving sewers. That is how the steel brush came to be used in our sewers. These two receiving sewers are 12-inch ironstone pipe. We have about fifty miles of 6-inch sewers in the different streets. I never found any fungous growth in any of them. We have very few stoppages in our sewers, and the causes of any come from house connections, carelessness of householders in stuffing anything in water-closet drains, and in not using sufficient water to flush house drains. We have at present about two hundred flush-tanks in operation on our sewers, and they give good satisfaction. . . . I do think that your system of sewers which we have in Alameda is a success. With proper care and sufficient flushing they can not be better. We are not troubled with sewer gas. The principal thing is to have the sewers well constructed, joints well cemented so that the sewer does not leak, and manholes every two hundred or three hundred feet apart.

## El Paso, Texas (Dr. W. M. Yandell, Health Officer):

(1) In the four years that the sewers of El Paso have been in operation there have been not a dozen obstructions, which have been removed at a cost not exceeding fifty dollars. (2) There is no growth of fungus in the sewers. (3) The general cleanliness and smooth working of the sewers is perfect. (4) There were 7,543 feet of 6-inch pipes originally laid by you. Since then there have been laid 11,700 feet of 6-inch pipes; total 6-inch pipe, 19,243 feet. (5) Have never found it necessary to use a steel brush—in fact, the sewers have never needed cleaning at all. . . . In fact, the sewer system is perfect.

4 Riverside, Cal. (Jas. W. Johnson, Esq., City Engineer) :

The only considerable length of 6-inch pipe in use is about 1,900 feet at the end of one of the laterals. There is a flush-tank at the end of it, and but few connections along its length. It is in excellent order. We have a number of 200-foot lengths of 6-inch pipe running from laterals into alleys. They are laid with a flat grade, have no flush at the end, and occasionally require cleaning. A larger pipe would be no better. We find no fungus in the pipes.

9 Chelsea, Mass. (W. E. McClintock, Esq., C. E.) :

There were about two miles of sewers built in part of Chelsea, Mass., during the summer of 1883. Perhaps a mile has been added to the system since that time. I have carefully observed the action of these sewers since their construction, at least to the time of my leaving the city work in April, 1890. My observations cover the whole length of the sewers and in all manholes. I cannot see but the pipes are as clean as they were after one month's use. There has not been automatic flushing since the first part of 1884.<sup>1</sup> Flushing has been had by means of letting on the water twice each month. There was no fouling up in the sewer except at the upper three hundred feet of dead ends. Our flushing removed all signs of fouling. The air was very good throughout, the system being only slightly polluted. We have about twenty-two manholes to the mile, and flushing as described at all dead ends. As I remember there are about 7,000 feet of 6-inch pipe, some of it laid on as flat a grade as 6 inches to the 100 feet. During my six years' care of these sewers I had two obstructions on the sewers, both on the 6-inch pipes. It cost us about \$5 to remove both of them. One was a brick getting displaced in a manhole and falling down in the outlet. Obstruction removed by rods. The second was a stick getting in the outlet of a manhole and making a dam. Located by rods and removed inside of a half day after I had notice of it. We removed one grease obstruction from a 4-inch house connection by using the rods; time, a half day to find and remove. We never used any kind of brush, except as above described. The flushing kept all clean. I never noticed any description of fungous growth in these sewers. I think there were traces of a green growth on the bricks of some of our manholes, but not enough to do any harm. We have just put in five or six miles in Gardner, Mass. My assistant, just returned from there, reports evidences of a fungous growth in some of the sewers which we call "beggatoa." It is a spongy substance, whitish and of quite rapid growth. If it continues it may tend to fill some of the pipes. I shall watch it very closely, and if it continues to grow shall see what can be done to stop its growth. I think Memphis must be an exceptional case as far as this growth is concerned, and I do not think it would make the least bit of difference whether the pipes were six or twelve inches: they would fill up if it grows as fast as it starts off to grow in the outlet pipe of our Gardner filter beds.

Norfolk, Va. (Wm. T. Brooke, Esq., City Engineer) :

We have in Norfolk about sixteen (16) miles of 6-inch sewers, portions of which have been laid at different times, covering a period of seven years. Therefore I have taken the number of stoppages during the last eighteen months only, as an example of our experience here. During the time specified we have had 126 stoppages, or an average of seven per month. These have cost us an average amount of \$6.50 for clearing the pipes, or a total of \$818, and a part of this amount has been expended in a general cleaning of the sewers in the neighborhood of each stoppage, so that it will be hardly fair to charge the whole to clearing the obstructions. The trouble we have found, in a large majority of instances, to have resulted not from any inherent defect in the sewer itself, but in a gross abuse of the purposes for which it was devised and intended, the last stoppage having been caused by some vagrant's taking off a manhole cover and throwing several

<sup>1</sup> Mr. McClintock means by this that the flush-tanks are not supplied by a constant stream. Twice a month the stopcocks are opened, and the tanks operate automatically until they are closed.

bricks into the line. Even then the bricks were carried a couple of hundred feet or more before they lodged. Again, it is a common thing to find yeast bottles, lumps of coal, razors, drawers-legs, segments of petticoats, door-knobs, old shoes, and such, at points of obstruction. I think, under such circumstances, that it is only a matter of wonder that more stoppages do not occur. . . . Now as to the question of fungous growth in the sewers, and the use of the steel brushes. We have used steel brushes from the beginning, not only on the 6- but on the 8-, 10-, 12-, and 15-inch lines. These brushes I have found invaluable for removing the accumulation of sand in our flat graded lines,<sup>1</sup> and for cleaning the pipes generally. I am not aware, however, of there ever having been anything like a fungous growth in our sewers, and Mr. Miller (whom you know) assures me that he has had no trouble with or knowledge of anything of the kind.

New Castle, Pa. (J. H. Miller, Esq., City Engineer) :

With reference to the operation of the sewers in New Castle, constructed in accordance with the plan furnished by you in 1887, I would say that I think no system could give more general satisfaction. We have at present in operation seven miles of pipe sewers, two miles thereof being 6-inch pipe. The first use of the same was in 1888. The only stoppages thus far have been one on the 6-inch line and one on the 8-inch line. Cost of removing the former was \$15.25, and of the latter, \$3, making a total in three years of \$18.25. You are probably aware that most of our flush-tanks are the Rhoads-Williams siphons. Our sewers, so far as I have been able to discover, and so far as reported by the plumbers in making connections therewith, are clean and in good condition. We have never used, nor found it necessary to use, a steel brush or any other appliance to remove fungus from any of our sewers, and I was very much surprised to learn of such difficulty occurring in sewers that were supposed to be regularly flushed. Perhaps we are congratulating ourselves too soon; possibly when our sewers have been in use for ten years we may have some trouble. We examine our flush-tanks once a month to see if they are working properly.

San Bernardino, Cal. (F. C. Finkle, Esq., C. E., City Engineer) :

I am sorry that I can say nothing favorable of our sewer system. The stoppages have been so frequent that we have not been able to keep track of the number, and the cost has been so great as to bankrupt the sewer fund of this city. We have taken up all 6-inch pipe and replaced it with 8-inch, which has remedied matters some. Fungus is growing in the sewers; especially was this the case with the 6-inch portion of the system. Our flush-tanks work perfectly, so that the difficulty is not blamable to them, and the gradients are good, being from one foot to two feet in each 100 feet. This city will never put in another foot of 6-inch sewer, the cost of keeping them clean is so great that it pays better to use larger pipes in the first instance.<sup>2</sup>

East Liverpool, Ohio (John G. Unkefer, Esq., C. E.) :

I was employed there by the board of sewer commissioners in the capacity of engineer during a period of eighteen months. The first six months were employed in sewer construction, and during the twelve succeeding months I had charge of the system, and superintended the plumbing work and construction of house connections. The length of the sewers is about ten and one half miles, 31,942 feet, or a little over six miles, being 6-inch pipe, and comprising the lateral sewers, which extend from the main sewer on thirty different streets, and through which nearly all the sewage must pass. At the upper end

<sup>1</sup> Nearly all of the sewers in Norfolk are laid in a very active and very fine quicksand, which finds its way through the smallest opening of the sewers.

<sup>2</sup> I have no knowledge of the plan under which these sewers were constructed, nor of the character of the work done. One or the other, or both, must have been singularly defective.—G. E. W., Jr.



or head of each line is placed a Field-Waring flush-tank of 150 gallons capacity, and by regularly flushing each line no trouble was experienced in keeping the sewers free from stoppages or growth of *any kind*. Not one cent was expended for removing obstructions (from use) in the 6-inch pipe during the time I had charge of the sewers. Neither a steel brush nor its equivalent was used to remove fungus. None was needed.

Wichita, Kansas (O. Mulvey, Esq., City Engineer) :

We have no 6-inch sewers in use here except some house connections, and therefore no stoppages in 6-inch sewers. Our smallest laterals are 8-inch, and since June 10, of this year, at which time I assumed control of the sewers since their completion, we have had only eight stoppages. The most of these were easily removed with the use of hose and fire hydrant. A few required the use of rods and scraper. Our system has been in use only since January last.

Keene, N. H. (P. F. Babbidge, Esq., Superintendent of water-works and sewers) :

When I assumed the office of superintendent, the sewers had been in use about five years. During this time but little attention had been paid to them, and no balls had been run through the lines at all. Of course I found the lines in rather bad condition, but had no trouble in cleaning them with balls and a liberal use of water, except in a few cases, where roots had got into the pipes through imperfect joints, or, as in one case, when we got a lot of bottles out. The fungous growth you mention I have never noticed in the 6-inch lines to any extent, or at least the balls have always cleaned it out. I have noticed the fungus in the large mains, but it has never caused any trouble to get rid of it. Our flush-tanks have always, and are now, working all right. I have done but very little work on the sewers this year and have not had a stoppage yet [November 20, 1891]. In 1890 it cost \$386 60 to clean, repair, inspect all plumbing work that was done, and in fact everything in the shape of labor that was done on the sewer system, and we have thirteen and one half miles in operation. We have 53,906 feet of 6-inch pipe. . . . The system complete to-day is as follows: 6-inch pipe, 54,106 feet; 8-inch, 2,745 feet; 10-inch, 1,380 feet; 12-inch, 3,852 feet; 15-inch, 9,065 feet;—total, 71,148 feet. The system is flushed by fifty-two Field-Waring flush-tanks, all of which work all right and keep the lines free and clean with the help of an annual running of balls through the pipes, which is done by three men in about two weeks at a cost of about \$65. . . . Eight hundred families (estimated) are connected with the sewers. . . . The cost of maintenance for the year ending Dec. 1, 1890, was \$823.53. This amount included the inspection of plumbing, all tools, and superintendent's salary. . . . The whole system here is working like a clock.

Pittsfield, Mass. (W. R. Plunkett, Esq.) :

I can't tell, in answer to your inquiries, the mileage of 6-inch sewer pipe laid here: and the records of the different boards of commissioners were so kept that it would require some measuring to find out. I never heard that there was any fungus in our sewers. There have been times, not often, when the smaller sewers have been stopped by rags, shavings, or sticks. This generally occurs below where a new house has been built.

Stamford, Conn. (W. B. Pierce, Esq., C. E.) :

The number of stoppages recorded in Memphis gives it a remarkable record in more than the yellow-fever. One would almost believe somebody had been making a business of clogging the sewers for reasons of their own. . . . Compared with Memphis our record is excellent. Since the first connection was made on Nov. 23, 1887, there have been but five or six stoppages in the whole system, and of these all except one were

in the 4-inch house drains. The exception was on Guernsey Avenue sewer, where, through a loose joint or cover, a quantity of sand caused a small obstruction, which four men removed in a couple of days. The house drains were all stopped by grease and other improper substances. No record was kept of the cost of removing obstructions. Our system is mainly composed of 6-inch and 8-inch pipes, there being about nine miles of the 6-inch and two miles of the 8-inch, in a total length of a trifle less than fourteen miles, the entire system. Whenever the Ys or manholes have been opened, observations have been made as to the clean condition of sewers. We have noticed a little fungus on several occasions, but not enough to ever cause any trouble. It is always at the water line, and detaches itself without any help other than the flushing. We have never had occasion to use brushes, rods, or anything else to remove it. We have never had occasion to clean any of the sewers except the Guernsey Avenue sewer already noted.

San Diego, Cal. No response has been received from this city, and I have no later information than that contained in the report of the superintendent of sewers to December 31, 1890, in which he says,—

Ten stoppages of the pipes have occurred within the year, and have promptly been relieved without great expense to the city and without serious embarrassment to the citizens.

The length of 6-inch sewers in San Diego is over thirty miles.

Mr. T. J. Graham, of Memphis, who, as a dealer in sewer-pipe, has kept close watch of the sewers from the first, and who was a member of the city council from 1882 to 1890, writes to my correspondent :

It is known that when Col. Waring's system was put in here it was the first general system of that kind ever put in, and while Col. Waring was here, from January to June 1880, a little more than 18 miles was built,—rushed through regardless of weather or high water, which seriously interfered with the proper laying of pipes. It would not be very wonderful if work done under such circumstances should show some defects as time goes on.

But the great matter that concerns the people of Memphis most is this : In the remedying of these troubles, that most vital of all the points in our system, *their sanitary efficiency*, has been overlooked or disregarded, and only the mechanical working of removing a certain sewage flow studied and provided for.

When Col. Waring came to Memphis, he found no sewers (except about four miles of private lines), and he found the earth's crust honeycombed with privy sinks, the number of which ran away up in the thousands. It was determined to clean out all the sinks, disinfect them, and then fill them with fresh clay ; put in the sewer system, and also lay drain tile to prevent, as far as possible, the excess of moisture carrying the poison to the surface, and to facilitate the soil-cleansing process by the rain-fall carrying down to the drains matters deleterious to health, and by placing them below the grade of the sewers to maintain the sewer system free from disturbance caused by the bad soil in which they were laid.

The most important part, in fact the vital principle in the Waring system, is the Rogers-Field automatic flush-tanks, or the question of flushing. Anyone that knows anything at all about this system of sewers, is aware that they must be flushed regularly and often, or they become a curse instead of a blessing. They must be washed, or flushed at the least, once in 24 hours.

The flush-tanks here work automatically. The water used up to 1890 was muddy, and carried often as much as 40 per cent. of its bulk in sediment. This sediment settled in the tanks, so that it seriously interfered with the proper working, and for some time a man was employed to look after them and clean them out, but since 1890 we have had nothing but clean water "as clear as crystal."

The man that formerly cleaned out the mud from the flush-tanks was released, and

since that time, about one and a half years, they have been examined "semi-occasionally," and as I write, fully 50 out of 257 flush-tanks do n't work at all, and over 75 of them flush perhaps once in three or four days, and there are not over 150 out of the whole lot that work properly, principally because the castings are corroded.

This is what I call a lack of sanitary efficiency, and a want of sanitary appreciation on the part of somebody, presumably those in charge, and so far I think it can readily be seen that the fault is in the administration and not the projectors of the Waring system.

The obstructions, which have caused much fear in the minds of those who have been looking after the sewers of our city, are not the faults of the system, but arise from various causes, the principal one of which was that, when a stoppage occurred in a 4-inch house-drain, a plumber used to go with a long plunger, made to fit 4-inch sewer-pipe, and force out the obstruction, no matter what it was, into the lateral lines, where the city had to go to the expense of removing it.<sup>1</sup> Such things became so frequent that a plumbing inspector was appointed, and new laws made, and new rules drawn to govern such cases, and yet it is still difficult to prevent trouble of this kind in the older part of the city.

Another reason why the obstructions in Chelsea would never be anything like so frequent as in the older sewered portions, is that it is not so thickly settled, and the principal portion of the population is made up of people who own their own houses, and who would have to stand not only the expense, but the inconvenience, of such stoppage or obstructions, and therefore, as a class, they are much more intelligent users of the sewers, with their value, from a sanitary point of view, ever before them. Of course, any sewer serving such a population as this, would fare infinitely better in the matter of obstructions than sewers in the alleys of the heart of the city, largely used by an ignorant colored population.

Major J. H. Humphreys, who was for some time the principal assistant engineer at Memphis, who resides there, and who has, for the past twelve years, been much interested in sewerage work, writes that he thinks that experience has shown that economy requires the use of man-holes, and that nearly all the stoppages were in the 6-inch pipes. He reminds me that he expressed the opinion in 1883 that 8-inch pipes should be used as a minimum. Concerning the defects developed in Memphis, he says,—

I cannot see how they detract materially from the credit which is your due for introducing here the separate system, which has been so extensively imitated by towns and cities in the United States. Nor do I see anything in the facts which constitutes an argument against the separate system as such. I am now more in favor of the system than at any previous time, both on economical and sanitary grounds. Would it not, on the other hand, have been without a precedent, if the system had been so perfect that experience could point out no changes that were desirable.

Accounts of the Memphis work attracted some attention in Europe. By request I prepared a paper for the Sanitary Institute of Great Britain, which was read at its annual congress. In the course of discussion Mr. Rogers Field said,—

I agree with the president that it would have been better if there had been manholes on the sewers. At the same time, there were several very special features in this case which altogether took it out of the ordinary category. Not a single old drain or street gully was connected with the sewers, and all the house-drains were strictly limited to

<sup>1</sup> Mr. R. Frank Hartford, for some time the engineer in charge of the Memphis sewers, told me personally, and one of his reports confirmed it, that the system was being seriously injured by such processes, and that he had been, thus far, powerless to prevent them.



4-inch pipes, so that nothing could get into the sewers that could not pass through a 4-inch pipe. All the service and branch sewers were automatically flushed every day by the discharge of the flush-tanks. The ventilation of the sewers was effected by an immense number of ventilating pipes, one of these being carried up every single house. *These conditions were altogether unprecedented*, and they could, therefore, hardly judge of the works by the rules applicable in ordinary cases.

Mr. Lavoinne, then chief engineer of the department of Rouen, wrote a paper describing the principles of the system, in the course of which he said,—

While understanding that municipal bodies should hesitate to undertake a general transformation which would devolve upon them expenses and responsibilities which now fall upon the owners of private property, it is nevertheless desirable that trials should be made in the new direction indicated by Mr. Waring. These trials would not be costly, and they might lead to the solution of a question at once important and radical and of the highest interest to the public health.

Mr. Lavoinne wrote me, privately, that the sewerage of the city of Memphis had solved the sewerage problem of Paris.

In 1883 a small section of Paris, in a district called "The Marsh," was seweraged on this system by order of the public works department, under the direction of Mr. E. Pontzen. This work was described in a pamphlet entitled "*Première Application à Paris en 1883 de l'Assainissement Suivant le Système Waring*, par Ernest Pontzen, Ingénieur Civil. In this Mr. Pontzen says,—

The first application of sewerage according to Waring's system, made in Paris in 1883, in a quarter where all of the unfavorable conditions are combined, has been a complete success. The establishments drained by Waring's system leave nothing further to be desired in a sanitary point of view, and the *ensemble* of the drainage-works has not, during the five months it has been in operation, given rise to the least complaint. The water-closets in the court-yards are no longer offensive, and their presence would not be suspected; the conduits of the system have never required any special cleansing; no deposit has been formed in the collecting sewer in the Rue de Rivoli at the mouth of the main, and the air in this main, constantly renewed and passing only over recent matters moving in a rapid current of water, has no odor. The officers of the city and the members of the municipal council more particularly interested in the improvement of the sewerage of Paris have watched the experiment with interest, and I am permitted to say that the good services rendered by the combined arrangements introduced by Mr. Waring contributed largely to the influence which led the municipal council to decide, in its session of April 11, 1884, that the preliminary official inquiry which is about to be made, and which is the prelude of a definite decision as to the method of sewerage of Paris, should relate both to the direct discharge of household wastes into the existing sewers, and to their removal by separate sewers. . . . This is one of the great advantages of Waring's system of sewerage, that it can as well be established in isolated sections, constituting an auxiliary and an economical complement of the great system of sewers, suited to receive fresh faecal matter and household waste, as it can, by itself alone, be extended for the complete drainage of whole quarters or of entire cities. Whatever may be the extension of a series of sewers according to Waring's system, it retains, always, by reason of its exclusion of storm-water, the great advantage of requiring only small diameters and reasonable inclinations in which the volume of flow undergoes only slight variations, and for the cleansing of which relatively small quantities of water suffice.

When the question of making an appropriation for my compensation came up in the city council, Mr. Alphand, the director of works, said,—

As to Waring's system, established in a quarter where the flow of matters is considerable, it has produced results. It was believed before that a special sewerage could not work in the sewers without the employment of suction or pressure. The trial of Waring's system has proved that by the simple natural fall of sewers, and by intelligent flushing applied to the water-closets, we may so dilute the matters as to render them sufficiently liquid to cause them to flow through pipes. It has been said that the demonstrations have not succeeded because during a period of trial three obstructions have occurred. Permit me to reply that this itself rather indicates success, because only three obstructions in such a considerable length indicate that the system has a real value. I want to say this very clearly, because by the terms of the report of the commission it might be thought that these trials have not been conclusive.

I am informed that this system is now used to a considerable extent in Paris, for the sewers of outlying districts, bringing them into connection with the large sewers.

Mr. A. Vescovali, chief engineer of the municipal service at Rome, wrote in 1885,—

You ask my opinion of Waring's system. I reply that I consider it excellent and preferable in practice to all of the more or less complicated systems that have been devised in these later times. I have proposed an application at Rome, but the municipal administration do not care to hazard a change from the old combined system that we have had since the ancient Romans. This system is, in fact, very good for us, because we have an abundant water supply which we can use without stint; but in the new quarters I think it would be well to adopt Waring's system with all its flush-tanks. This system would, in my opinion, be excellent if you could deliver its outflow at a distance in the sea, as you propose, but that, perhaps, would be difficult for want of fall. . . . I still think it is preferable to all mechanical systems, wherever, because of insufficient water, the combined cannot act efficiently. I am a declared partisan of the combined system, which is the system used in Rome since its foundation. Our old and very imperfect sewers are a proof of the goodness of the system, because, with the abundant streams of water flowing through them, they are, in spite of their imperfections, free from objection and produce no bad odor. In the new quarters, on the contrary, although the sewers are better constructed and on a much better system, the odors are very troublesome. You know we have had to have recourse to periodic flushings with Field's siphon.

About 1888, Mr. J. G. W. Fijnje, one of the most distinguished engineers of the Dutch government service, wrote a paper on the sewerage of The Hague, in which he recommended the adoption there of Waring's system.

It is hardly necessary to refer to the great extension of the system here, several of our largest engineers occupying themselves almost exclusively with the construction of sewers for the smaller towns according to the system first introduced in Memphis, incorporating with it, of course, the improvements which the experience of the last twelve years had suggested.

It should be a source of satisfaction to the members of this Association to know that a process of sanitary improvement, which has secured such wide adoption, first originated in a paper read at one of its annual conventions.

(Since the foregoing was prepared for press the following have been received.)

Laconia, N. H. (S. B. Smith, Esq., Chairman of sewer commission):

The sewerage system put in by you, and now in use here, is giving perfect satisfaction. There have been no "stop-ups" and the flush-tanks have kept the pipes comparatively clean. I am especially pleased with the workings of the two main outlets and the "inverted siphon" under the Winnipiseogee river, with which we have had practically no trouble.

Stamford, Conn. (W. B. Pierce, Esq., C. E.):

The condition of the sewers in Stamford has not altered materially during the past year, except that more houses have been connected, and that we have put in two extensions amounting to about 1,400 feet of 6-inch sewer. After five years' use, the sewers are being cleaned for the first time, and during that period there has not been one stoppage in a sewer, and not more than a dozen in the house drains. Have been over about three quarters of the system, and find practically no deposit. To-day we have 555 connections.





